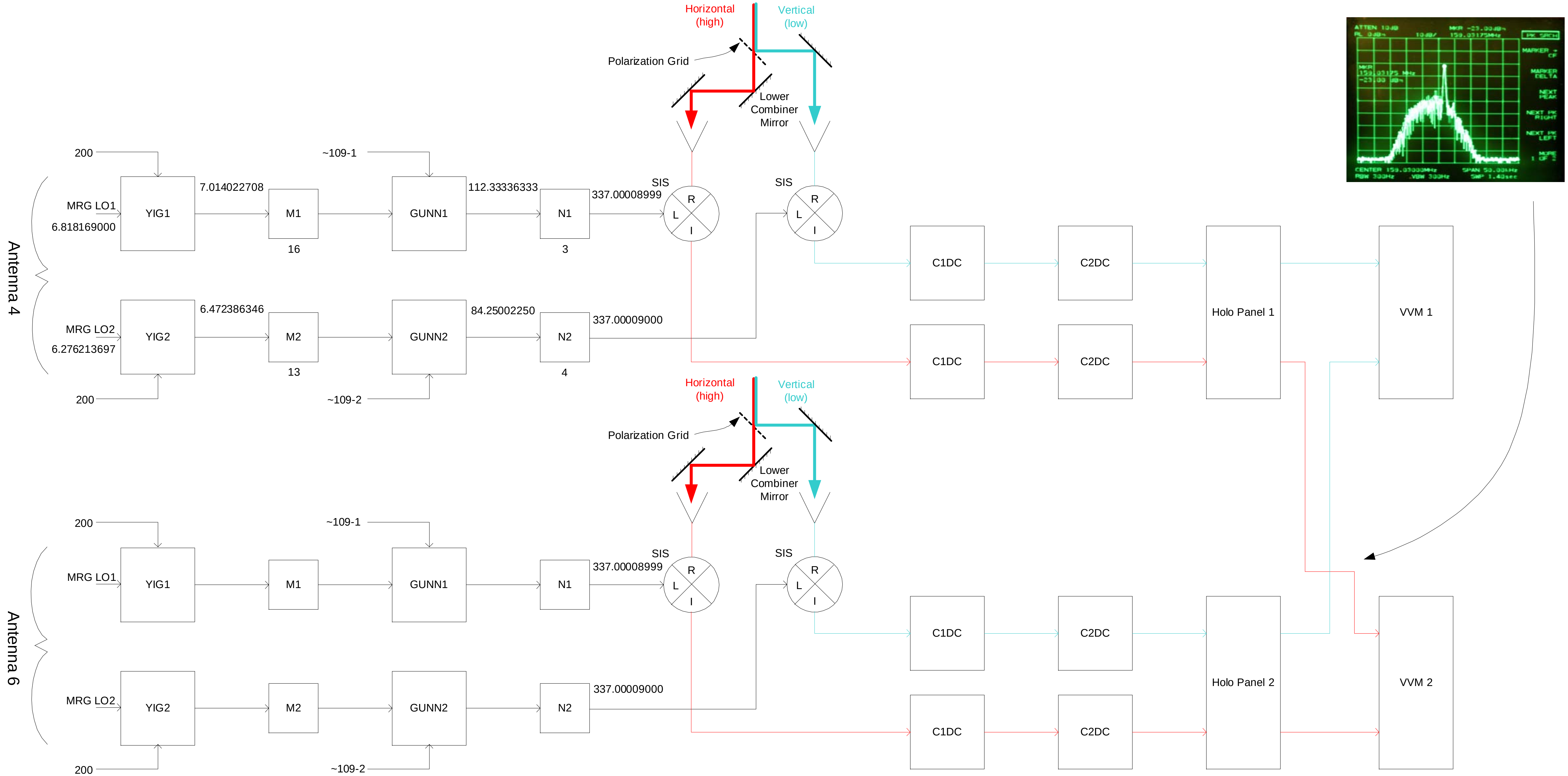

Estimated phase noise of low frequency LO = sqrt[(0.25 * 16)^2 + 2^2]*3 = 13.42 degrees RMS

Predicted phase noise at VVM1 = sqrt[(13.42^2 + 13.42^2] = 18.98 degrees RMS

Estimated phase noise of high frequency LO = sqrt[(0.25 * 13)^2 + 2^2]*4 = 15.26 degrees RMS

Predicted phase noise at VVM1 = sqrt[(15.26^2 + 15.26^2] = 21.58 degrees RMS

Recent holography results have shown an RMS of ~20 degrees which is consistent with these predicted numbers

In actual practice the receiver (SIS + HEMT) adds a non-trivial amount of thermal noise to the beacon signal. This noise would normally be vector summed with the desired beacon signal to produce an apparent increase in phase noise. Fortunately TK's holography panel utilizes a fairly narrow BPF (10dB BW ~15kHz, see plot above) to remove most of the thermal noise. The beacon tone power as seen at the holography panel test point is -23 dBm while the noise power integrated over the pedestal is -62 dBm. This level of thermal noise will introduce an additional ~0.7 degrees RMS of phase noise to the beacon tone but can be considered negligible in comparison to the final LO numbers of 13.4 and 15.3 degrees RMS for the 200 & 300 Rxs, respectively.

Another issue to think about in regard to phase noise is that the MRG LO, 200 MHz, and ~109 MHz references from the analog room to the different antennas may have some common phase noise. E.g., the MRG LO generated in AR9 has some non-zero phase noise which will be common or coherent to all antennas. If this is the case then the common phase noise portion should be removed by the VVM resulting in numbers << 20 degrees RMS. We don't see that. One possible explanation is that the majority of the 0.25 degrees RMS phase noise seen from the antenna YIGs is generated independently for each antenna (E.g., generated within the fiber links) and therefore does not cancel.

Phase Noise Discussion on Recent Holography Results

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2007 Aug 1

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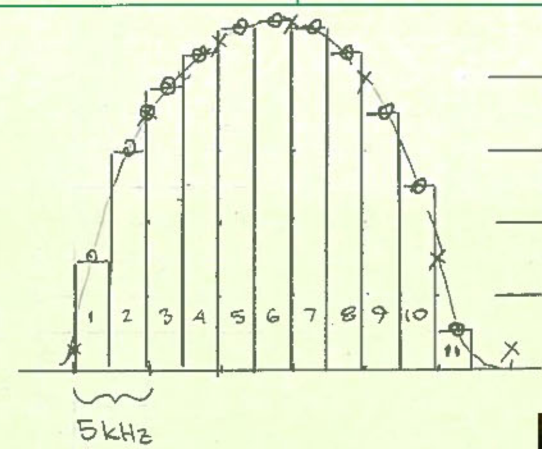


$-50 - 52 = -102$ dBm/Hz

$-60 - 52 = -112$

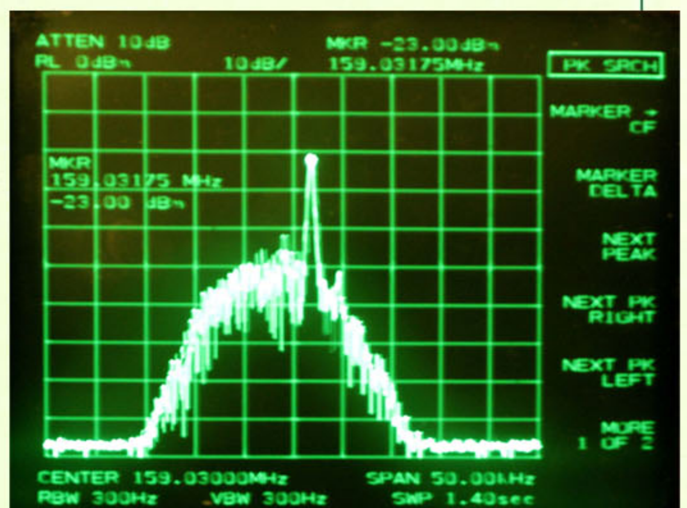
$-70 - 52 = -122$

$-80 - 52 = -132$

$-90 - 52 = -142$

$-100 - 52 = -152$

1	−137	→	2×10^{-14} mW/Hz
2	−122	→	6.3×10^{-13}
3	−114	→	4.0×10^{-12}
4	−109	→	1.3×10^{-11}
5	−105	→	3.2×10^{-11}
6	−104	→	4.0×10^{-11}
7	−105	→	3.2×10^{-11}
8	−109	→	1.3×10^{-11}
9	−117	→	2.0×10^{-12}
10	−127	→	2.0×10^{-13}
11	−147	→	2.0×10^{-15}



$\Sigma = 1.37\times10^{-10}\ \frac{mW}{Hz} \cdot 5\times10^{3}\ Hz = 6.84\times10^{-7}$ mW

$= -61.6$ dBm (noise)

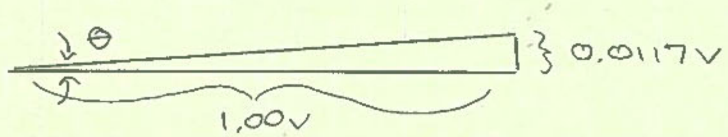
Beacon tone $= -23.0$ dBm

Noise is -38.6 dBc

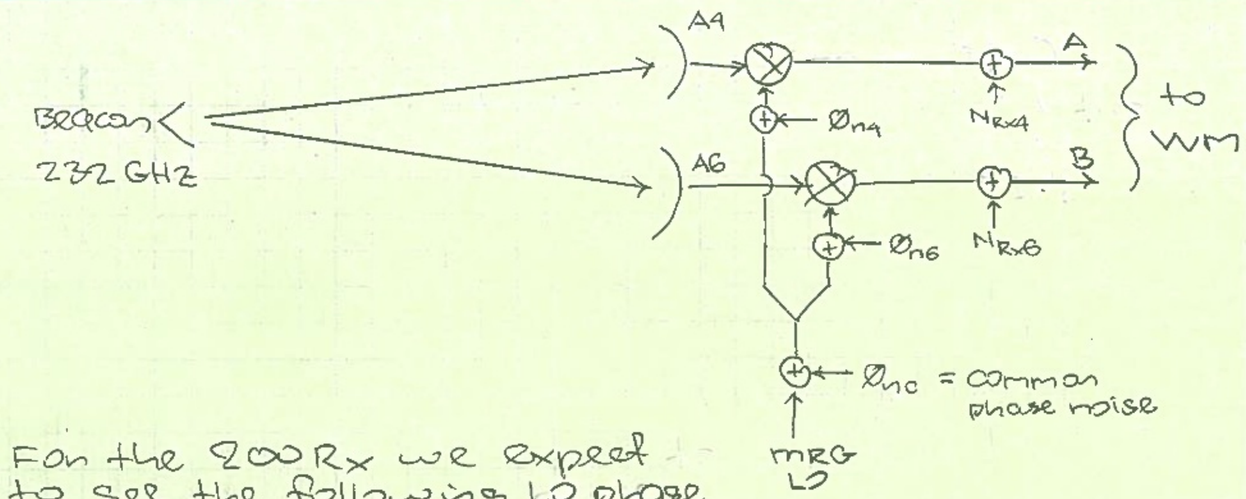
$20\log\frac{V_{noise}}{V_{signal}} = -38.6$ dB

let $V_{signal} = 1\ V_{rms}$

$V_{noise} = 0.0117\ V_{rms}$



$\frac{0.0117}{1} = \tan\theta$, $\theta_n = 0.67°$ ← Thermal Noise Pedestal adds this much Ø-Noise to Beacon



For the 200 Rx we expect to see the following LO phase noise entering the SIS mixer

$[(0.25\cdot16)^2 + (2)^2]^{1/2}\cdot 3 = 13.42°$ RMS

(0.25 — YIG Ø noise; 16 — M; 2 — Gunn Ø noise; 3 — N)

Assuming for now that the LO phase noises for antennas 4 & 6 are entirely incoherent (I.e., $Ø_{nc} = 0°$) we expect the following phase noise at the VVM output ($\angle$ B−A):

$(13.42^2 + 0.67^2 + 13.42^2 + 0.67^2)^{1/2} = 19.00°$ RMS

(A4: LO $Ø_n$, Rx Thermal; A6: LO $Ø_n$, Rx Thermal)

↑ we actually see ~20° RMS

This implies that $Ø_{nc}$ is nearly 0° RMS

I.e. The ~0.25° RMS seen @ the YIG outputs is a true measure of incoherent phase noise